

A1
contd

composition is preferred since the SURLYN 1706 is more viscous and has a somewhat higher melting temperature. The properties of the SURLYN 1705-1 product as a resin and also in sheet form are set forth in Tables I and II respectively:

Page 10 -- please replace the first paragraph with the following new paragraph:

A2
Sub
B1

In accordance with the preferred embodiment of the invention, additives for mitigating UV-induced photo-oxidation are incorporated in the zinc ionomer. Preferably the additives are added in amounts ranging from about 0.3 to about 1.0 wt. % and consist of a UV light absorber in the form of Tinuvin 328, a product manufactured by Geigy Chemical Corporation of Ardsley, New York, which is believed to be 2-(2H-benzotriazol-2-yl)-4,6-ditertpentylphenol, and a UV stabilizer in the form of Chimasorb 944, also a product manufactured by Geigy Chemical Corporation, which is identified by the manufacturer as a sterically hindered amine light stabilizer (commonly identified as HALS).

Page 10 -- replace the second paragraph with the following new paragraph:

A3
Sub
B2

Test specimens, each comprising two 0.010 inch thick layers of Surlyn 1705-1, modified with 0.3 wt % Tinuvin 328 and about 0.3 wt. % Chimasorb 944, disposed between and bonded to two sheets of glass, showed improved radiation transmission in the 400 to 800 nm wavelength region and, more importantly, the specimens resisted photo-oxidation and maintained their high transmission properties in that wavelength region without discernible color alteration after prolonged and intense radiation stress exposure. More specifically, the test specimens were made using two different glasses. In one case, the front and back glass sheets were Solatex II glass (a tempered solar grade glass). In the other case, the two glass sheets were a borosilicate glass. Figs. 1 and 2 illustrate the radiation transmission curves for test specimens made with Solatex II glass and borosilicate glass respectively. It is clear that in both cases, the transmission

Sub
B2
Cont'd

property for each specimen after 8 months exposure to the test condition is virtually the same as what it was immediately after fabrication and before testing.

Page 13 -- please replace the first paragraph of the example (lines 5-25) with the following paragraph:

Example

A4
A sheet of tempered solar grade CeO-free glass, having a thickness of 3/16 inch, is placed face down on a supporting surface. Two 0.010 inch thick corona-treated sheets of Surlyn 1705-1 zinc based ionomer, modified with 0.30% Chimasorb 944 and 0.30% Tinuvin 328, are placed over the top surface of the glass sheet. An array of inter-connected silicon solar cells made from rectangular polycrystalline EFG-grown wafers is placed on top of the two Surlyn 1705-1 sheets, with the front contacts of the cells facing the glass sheet. The conductors interconnecting the solar cells have been soldered to the front and back contacts of the cells using a tin/silver solder as prescribed by Gonsiorawski in U.S. Patent No. 5,074,920, and an acidic carboxylate flux. The ionomer sheets are oriented so that the corona-treated surface of one sheet engages the glass sheet, and the corona-treated surface of the second sheet faces the array of solar cells. A scrim layer with a thickness of about 0.005 inch is placed over the array of solar cells in contact with the back contacts of the cells and the interconnecting conductors. Then another 0.010 inch thick sheet of the same modified Surlyn 1705-1 zinc ionomer is placed over the scrim with its corona-treated surface facing away from the scrim, and that ionomer sheet is covered by a back sheet of Tedlar. The Tedlar has a thickness of approximately 0.0015 inch. The resulting sandwich-like assembly is placed in a vacuum press and laminated.

Pages 14 and 15 -- please replace the last paragraph on page 14 and the first paragraph on page 15 with the following new paragraph:

A5
Panels incorporating silicon solar cell modules made according to the present invention, e.g., as set forth in the foregoing example, have passed stress

AS
Control

tests of 1000 hours of 85% RH/85° C damp heat as well as the humidity-freeze cycling (85/85 to 0/-40) for 20 cycles without decreased electrical photovoltaic performance while fully satisfying the safety criteria of the wet and dry high voltage withstand tests at 3600 volts as well as the insulation resistance criteria measured at 500 volts. This success using a Tedlar substrate is because the zinc ionomer encapsulant has a low water solubility which when coupled with the encapsulant's strong adherence capability avoids premature voltage breakdown and significant current conduction paths from cells to ground. By way of comparison, the zinc Surlyn 1705-1 material has a water absorption of 0.3 wt. % in comparison to the sodium Surlyn 1601 and EVA which have water absorptions of 3.0 wt. % and 0.7 wt. % respectively. Moreover, the condition of the physical structure of the solar modules is virtually unchanged from its pre-stress state and that includes the absence of (a) liquid water droplets that cause other encapsulant systems like EVA to become hazy and (b) the development of blisters beneath the Tedlar substrate resulting from hydrolytic attack at the underlying encapsulant interface.

Replace the paragraph on page 16 and ending on page 17, third line, with the following new paragraph:

AB

Obviously it is possible to modify the components of the solar modules and the method of laminating the components without departing from the scope of the invention. Although modules made according to the invention using a non-CeO doped glass as the front panel show advantages over the prior art with respect to the ionomer encapsulant resisting photo-oxidation and maintaining solar radiation transmission in the 400 to 800 nM wavelength range and are preferred due to the reduced cost of such glass, the invention may be practiced using a CeO-doped solar glass front panel where cost is not a controlling factor. Also the glass front panel may be replaced by a sheet of a transparent plastic material, e.g., a polycarbonate or an acrylic polymer, while the backskin or rear panel may be made of glass or some other transparent, translucent or opaque material, e.g., a multi-composition laminate. It is also within the scope of the invention to vary one

or more of the parameters of the laminating process, including but not limited to: (a) the rate at which the components are heated up to the desired maximum temperature, (b) the rate at which the compressive pressure exerted on the modules is increased to the desired maximum level, and (c) the length of time that the components are subjected to the maximum temperature and pressure conditions. The number and thickness of the zinc ionomer sheets used in making the module also may be varied. The Surlyn 1705-1 zinc ionomer may be replaced by the SURLYN 1706 zinc ionomer which also has a high radiant energy transmissibility. However, use of the SURLYN 1706 zinc ionomer is not preferred since it requires that the lamination proceed at a temperature in the range of about 160°C to about 185°C. Other zinc ionomers resistant to acids and having a comparable low moisture absorption also may be used so long as they meet the following requirements: acceptable light transmission, adequate bonding adherence, high melt flow, and resistance to photo-oxidation. It is to be understood also that the other UV absorbers and stabilizers may be found to be acceptable substitutes for the Tinuvin 328 and Chimasorb 944.

A6
Cont'd

Pages 17 and 18 -- please replace the second paragraph on page 17 and the first paragraph on page 18, with the following new paragraph:

Also the invention may be used in the manufacture of modules comprising different forms of solar cells known to persons skilled in the art. Silicon solar cells of the type contemplated herein and also in U.S. Patents Nos. 5,478,402 and 5,476,553, supra, comprise silicon wafers with a p-n junction formed by doping, as disclosed, for example, in U.S. Patent No. 4,751,191, issued 6/14/88 to R. C. Gonsiorawski et al, and U.S. Patent No. 5,178,685, issued 1/12/93 to J. T. Borenstein et al. The invention may be used also in modules that comprise other cells formed independently of one another but interconnected by soldered conductors, notably cells comprising a semiconductor substrate such as germanium or gallium arsenide onto which one or more layers of another crystalline material are epitaxially grown to form one or more junctions, as

A7

disclosed, for example, in U.S. Patents No. 5,944,913, issued 8/31/99 to H. Q. Hou et al. and U.S. Patent No. 6,252,287, issued 6/26/2001 to S. R. Kurtz et al. The invention also may be incorporated in modules that comprise so-called thin film solar cells. Typically such solar cell modules are produced by depositing several thin film layers on a substrate such as glass, with the layers being patterned so as to form a plurality of individual cells that are electrically interconnected to provide a suitable voltage output. Depending on the sequence in which the multi-layer deposition is carried out, the glass substrate may function as the back surface or as a front window for the module. By way of example, thin film solar cells are disclosed in U.S. Patents Nos. 5,512,107, issued 4/30/96 to R. van der Berg; 5,948,176, issued 9/7/99 to K. V. Ramanathan et al.; 5,994,163, issued 11/30/99 to M. Bodegård et al.; 6,040,521, issued 3/21/2000 to K. Kushiya et al; 6,137,048, issued 10/24/2000 to X. Wu; and 6,258,620, issued 7/10/2001 to D. L. Morel et al.

AM
Control